THE WESTERN AUSTRALIAN
NATURALIST

Vol. 3. DECEMBER 20, 1951 No. 3.

SIMPLE SOCIAL BEES OF WESTERN AUSTRALIA

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INTRODUCTION.

The small bees in the genus *Exoneura* appear to be more numerous in the eastern than in the western part of Australia, and while one of us (Rayment, 1951) has already published on the biology of several eastern species, yet the habits of the western bees have hitherto escaped observation, although several species have been collected over the years.

Since this is the first account of these bees in Western Australia, it is given in some detail, and because the investigation was contemporary with the celebration of the "Jubilee Year" of the Commonwealth, the authors deemed it appropriate to mark the occasion by naming the new species *Exoneura illustris*. The bees have hitherto been regarded as solitary wild-bees, but it is now known that they are social in habit, having affinities with the African genus *Allodape*.

LOCALITY.

The Darling Range forms the wall of the western plateau, running approximately parallel with the coast, and about 15 miles inland. It is a laterite-capped series of rugged hills about 1,000 ft. above sea level, with massive granite rockfaces and outcrops. The steep gullies are usually dry in summer, but may become rushing watercourses in winter. Better soils are present in some of the gullies, but the gravelly ironstone slopes have proved worthless for farming.

The Ranges were cut over for timber in the early days, and some mills still operate there, but the hills have retained much of their original state chiefly because they are unattractive for cultivation. Large areas are reserved for water catchments and are consequently sanctuaries for the fauna and flora.

FLORA.

The trees of the Darling Ranges are predominantly jarrah *(Eucalyptus marginata)*, interspersed with marri *(E. calophylla)*. Wandoo *(E. redunca)* occurs chiefly about the fringes, and swampy ground may be marked by paperbarks *(Melaleuca parviflora)*.

Flooded gums *(E. rudis)* flourish along some of the watercourses, but in typical jarrah country there are lesser trees, such as *Banksia,* native pear *(Xylomelum occidentale)* and sheoak *(Casuarina Fraseriana).* Scattered throughout the area are the tree blackboy *(Xanthorrhoea Preissii),* and the drumstick blackboy *(Kingia australis).* There are thickets of *Dryandra floribunda;* various Acacias and a Zamia palm *(Macrozamia Reidlei).* In this company the Slender Blackboys *(Xanthorrhoea gracilis)* flourish. The smaller plants include *Hovea, Grevillea, Lesehenaultia,* poison plants, heaths, trigger plants *(Stylidium),* etc., so that no month of the year is entirely destitute of wildflowers.

Towards the end of December 1950, one of us (R.E.) was driving along the Perth-Albany Highway through the Ranges. About 40 miles south of Perth is an area of slender blackboys, plants which bear their crowns of "grass-leaves" near ground level. The slender flower-stalks are about four feet tall, and round the top for three or four inches is a dense "mat" of small creamy-coloured blooms, which are mostly evident in early sum-

Fig. 1.—Slender Blackboy *(Xanthorrhoea gracilis* Endl.). In the middle, flower head and tip of leaf. On the left, from top downwards, longitudinal section of flower; stamen, stigma, petal and bract; section of the flower head; section of the flower stem; section of the leaf. On the right, from top downwards, a flower from above; stamen; stigma; side view of a flower.

mer. There is little to be gained by investigating the sappy stalks. One must turn to the dry sticks of the previous year, and which have lost their "heads." When the black angular seeds develop the heavy "head" breaks the thin support, and falls off, leaving the pithy interior exposed to the weather.

Most of the dry stems contained nests of small reddish bees of the genus *Exoneura*. As slender blackboys are widely distributed through the Ranges, it is possible that these bees are equally numerous, although they had not previously been studied. Evidence of this was obtained later in the day, when the Main Eastern Highway was being traversed, and we were again in the Ranges. It was easy to collect numerous nests in other similar "headless" stems of slender blackboy. On subsequent visits, more "nests" were taken at several different points along this road.

TAXONOMIC DIFFICULTIES.*

The integument of these small bees is soft, smooth and shining, and the excessively delicate tessellate sculpture is general, and sometimes subobsolete. The systematist is unable to construct a satisfactory dichotomous key to the species in the absence of contrasting characters for the usual couplets. The clypeus, mandibulae, labrum, antennae, metathorax and wings offer no real value to the taxonomist; the legs are of only slight assistance. The wings and their neuration are remarkably stable, and no mutation has been found in the thousand or more species studied by the senior author (T.R.).

Many of the females are extremely difficult to separate, and new species should not be described in the absence of the male and/or the larvae. The difficulty is very evident in females of the *E. angophorae* group. The female bees have very little harvesting-hair, nor is there much need for a larger harvest, since there is no storage of pollen in cells.

The males are easier to determine, for the ivory-coloured face-marks are evident and stable, but clypeal stripe, if any, of the females, is variable. Valuable characters are to be found in the number and arrangement of the spines of the genitalia, and the form of the abdominal sterna. The gradulus, a transverse line on the ventral plates, and also the genitalia, can be examined only after they have been dissected out, and mounted for study under the microscope. The males are usually much more hairy than the females; a condition unique in the Apoidea.

The basal segment of the labial palpus is the longest in all of the mouth-parts studied by us, and neither the attenuated glossa nor the maxillary palpus offer any characters of taxonomic value; there is, of course, no pygidial plate. It is evident that the work of the taxonomist is of a critical nature.

*The taxonomic section is by the senior author (T.R.), who is responsible for the new names proposed.

Fig. 2.—Details of Morphology of *Exoneura illustris* Raym. 1—Genitalia of male bee *Exoneura illustris* Raym. 2—Anterior wing of female; note absence of second recurrent nervure. 3—Anterior view of head-capsule of male; note the ivory-coloured clypeus and lateral marks. 4—Labrum of female. 5—Posterior wing of female. 6—Lateral view of male pupa, *E. illustris*. 7—Ducts of pharyngeal gland which secretes the "pap" for the young larva. x 600. 8—Pharyngeal rods showing the position of the ducts of the pharyngeal glands. 9—Three of the abdominal sterna and the apical tergum of the male. The transverse line on the former is the gradulus, which is a specific character in several genera of bees. 10—Section of flower-stalk showing the one communal chamber drilled out of the pithy interior. 11—Strigilis of antenna-cleaner of anterior leg. 12—Mesophragma of bees, thin and springy, connects the bases of the smaller wings, and appears to have some function in their

Division XYLOCOPIFORMES

Family CERATINIDAE

Exoneura illustris, sp. nov.

Type, female—Length, 6 mm. approx. Black, red legs and abdomen.

Head long, shining, an extremely delicate sculpture; frons with a strong carina surmounting a high ridge between the scapes (the sides of the face are deeply excavated, as in *E. excavata*, and this formation throws up the clypeus and supraclypeal area); clypeus has numerous evenly-spaced well-defined piliferous punctures; vertex with rather large ocelli; compound eyes converging slightly below; labrum ivory-colour; mandibles black, with a subapical ivory mark; antennae black, scapes with an ivory line in front; genae shining, with a few white hairs.

Prothorax not visible from above; mesothorax smooth, bright, an exceedingly delicate cancellate sculpture, 12 or so large punctures, parapsidal furrows conspicuous; tegulae shining, black, with amber margins; tubercles black, with a fringe of long dull-white hair; pleura smooth, a few punctures, and sparse white hairs; scutellum similar to mesothorax; postscutellum rougher; metathorax with the dorsum very large, shining, and a coarser cancellate sculpture; abdominal terga ferruginous-red, basal one black, apical segments darker, with some whitish and blackish hairs; ventral segments similar.

Legs red, coxae, trochanters and femora basally black; tarsi red, hind basitarsi with a few black hairs among the golden ones; hind calcar reddish; claws reddish; wings subhyaline; nervures brown; pterostigma amber; hamuli five.

Allotype, male—Length, 5.5 mm. approx. Coloured like the female.

Head with more long white hair; face excavated as in the female; the entire clypeus ivory-coloured, and also two minute lateral marks which are pointed above; labrum ivory; mandibles ivory and amber; antennae black, an ivory stripe on the front of the scapes; the bulging compound eyes converge below, and the large ocelli are set in excavations in the vertex.

There is considerable white hair about the metathorax laterally; the sculpture of the mesothorax is similar to that of the female; the

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movements during flight. This appears to be overlooked in explanations of how the small wings are moved. 13—Larva appendage. 14—Antenna of male has thirteen segments. 15—Sting apparatus of female. 16—Larva before appendages are absorbed of *E. pictifrons* Alfk. 17—Calcar of posterior leg of female. 18—Claws of tarsus or foot. 19—The large salivarium, at the base of the glossa, is applied to the mouth of the larva when food is passed from the mother; the glossa being bent back over the head. 20—Anterior view of head-capsule of female. 21—Arrangement of hairs on distal margin of wing. 22—Within the thick dark base of the salivarium there is a group of pore-organs—indicated by arrow at 19. 23—Group of pore-organs on posterior coxa.

red of the anterior and median legs is pale-ferruginous, but the posterior pair is darker, almost black, with broad basitarsi and black hair. The femora basally have scopae of long white hair; thorax beneath has considerable white hair.

Locality—40 miles south of Perth, Western Australia, December 10, 1950.—Rica Erickson. Taken from a series of nests in stalks of *Xanthorrhoea* with a number of males and females.

Type and allotype, and "nest" series, in the collection of the senior author.

Allies.—Clearly close to *E. perpensa* Ckll. which is larger and the female of which has an ivory-coloured stripe down the clypeus. The structure of the ridge between the antennae is very different, and the basal segment of the abdomen is not black; the hind legs of *illustris* are darker; those of *perpensa* are not darker, being the same light colour as the others; the labrum is reddish-amber, and the clypeus has fewer punctures. The male *illustris* has very much more hair on the face and body than the male of *perpensa*. There is also a close resemblance to the male of *E. pictifrons* Alfk., which, however, has black hind legs.

Exoneura pietifrons Alfken.

Cockerell (1930) thought it remarkable that the genus was so poorly represented in Western Australia. He suspected that his female *E. angophorae occidentalis* was the other sex of *E. pietifrons*, thus leaving the State with only two species.

The senior author has been able to clear up Cockerell's doubts regarding the association of the sexes, and the junior author's collections, in 1950-51, demonstrated their true relationship. In a long series of females there is a considerable variation in the colours and the number of bands on the abdomen in specimens taken from the same "nest." The males often have a blackish band on each tergum.

The typical female has a bright-red abdomen, with a broad black band on at least each of the first three terga; the red of the abdomen may be ferruginous, with a band on each tergum; the scape may be red in front, or even dull-ivory, with the clypeus entirely black, or suffused anteriorily with an obscure reddish tint; the posterior legs are, however, very black; in only a rare specimen obscurely red.

The very dark terga of specimens from Rottnest Island show a more reddish margin, and Alfken regarded this form as a variety, *obscura*, of *E. pietifrons*, but it is distinct, and adequate structural studies show that it should be raised to full specific rank. The type locality of *obscura* is Mundijong.

Some of the females of *E. pictifrons* have only the basal segment of the abdomen black, and these are apparently Alfken's variety *laeta*, which then approaches *E. illustris*, but the variety has very black posterior legs similar to those of the species. *E. illustris* has red legs.

The type (female) of Cockerell's *E. angophorae occidentalis* was taken at Yallingup by R. E. Turner 1914. The type was compared by Meade-Waldo, at the British Museum, with *E. bicolor* Sm., and he reported: "Not *E. bicolor;* differs in colour of the legs."

In the author's preparations of the morphology of western *Exoneura,* the apical sternum of the males is more or less bidentate, and has some value as a specific character. Microscopical studies demonstrated that the two bees are very closely related, but are distinct, and nearest to the eastern species, *E. perpensa* Ckll.

The bees of the minute black species, *E. albopilosa* sp. nov., do not approach any other of the bees discussed in this paper, but appear to be related to the eastern species, *E. rufitarsis* Raym., which have similar red tarsi, but are larger, and more robust bees.

Exoneura albopilosa, sp. nov.

Type, male—Length, 5.5 mm. approx. Black.

Head quadrate, and very large for so small a bee; frons excavated deeply around bases of scapes, and up to level of lateral ocelli, shining; clypeus of a peculiar shape, with a well-defined longitudinal lineation, and long loose white hair; at sides of clypeus the integument is polished; supraclypeal area elevated, and rising to a ridge surmounted by a fine carina that reaches the median ocellus; the bulging compound eyes converging strongly below; labrum large and black; mandibulae simple, basally black, apical third amber; scapes black, flagellum amber beneath; the median ocellus placed on a flat area formed by the apex of the ridge on the frons; vertex long.

The whole of the shining integument has a delicate tessellate sculpture, with many long loose white hairs, except on the scutellum, where the hair is black; the sculpture of the metathorax is coarser and scale-like. The abdominal terga are narrowly amber on the posterior margins, and the apical segments are quite rough; long microscopically-plumose white hair. Tegulae and tubercles black; the pleura having much long white hair.

Legs black; tibiae suffused with reddish; tarsi pale-amber to ivory-colour; the hind basitarsi large, white hair; wings iridescent; nervures sepia, the first recurrent practically meeting the first intercubitus; second cubital cell very large; pterostigma brown; hamuli six, weak; calcariae finely serrated, golden yellow.

Locality.—40 miles south of Perth, Western Australia. Bred out of *Xanthorrhoea* stalks by Rica Erickson, January 1951.

Type and paratype in the collection of the senior author.

Allies.—This is an excessively small species, not a typical *Exoneura* and very distinct by the characters of the genitalia. It approaches *E. rufitarsis* Raym. (from Victoria), but not very closely. *E. rufitarsis* is a larger bee, with a small head and is almost nude on the head, thorax and abdomen; it has a yellow clypeal stripe, labrum and tubercles, but red tarsi.

Exoneura minutissima, sp. nov.

Type, female—Length 3 mm. approx. Black, polished, with reddish legs.

Head almost circular from the front, practically nude; face deeply excavated laterally; frons with a fine carina reaching the medium ocellus; clypeus with the carina extended nearly down to the labrum, practically impunctate; supraclypeal area with continuous carina; vertex with the delicate tessellation more evident; compound eyes converging below; genae with a few white hairs; labrum obscurely amber; mandibulae black, acute; antennae black, some obscure red on scapes.

Prothorax black; tubercles amber, with long white hair (black in *E. albopilosa*, ivory in *E. rufitarsis)*; mesothorax shining, almost polished, but excessively delicately transversely striate; scutellum similar; postscutellum rougher, with some white hair; metathorax with the dorsum depressed into a transverse channel, the tessellation is most evident on this part; abdominal dorsal segments shining, transversely striate, a few piliferous punctures, and white hairs; ventral segments with a few longer white hairs.

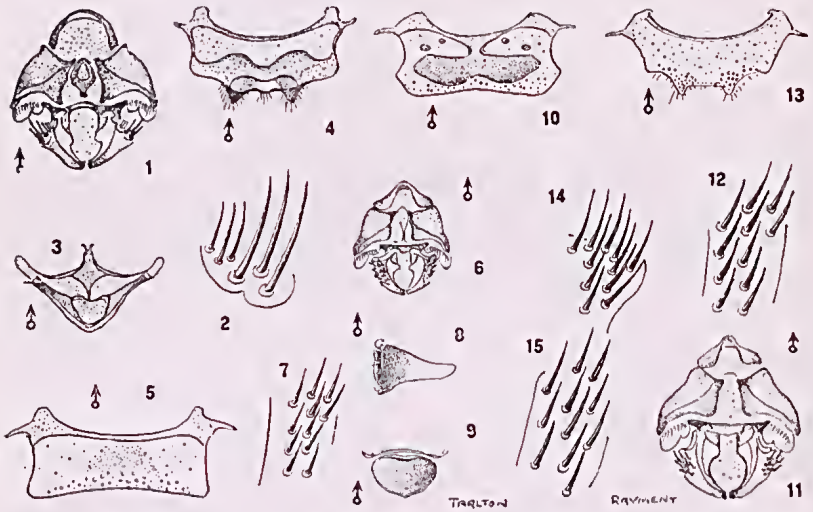

Fig. 3.—Details of male *Exoneurae*. 1—Genitalia of male *Exoneura obscura*, Alfken et Rayment. 2—Arrangement of spines. 3—Another view of gonobase of genital capsule. 4—The bidentate sternum of the male abdomen has value as a specific character. 5—Third sternum of the abdomen (compare with No. 9, Fig. 2). 6—Genitalia of male *E. albopilosa* Raym. 7—Arrangement of spines. 8—Mandibles are simple in males, and have no specific value. 9—Labrum is black, and not typical of the genus (compare with No. 4, Fig. 2). 10—Third sternum of male abdomen (compare with No. 9, Fig. 2). 11—Genitalia of male *E. pictifrons* Alfk. 12—Arrangement of spines. 13—Apical sternum of male abdomen. 14—Arrangement of spines of *E. perpensa* Ckll. 15—Arrangement of spines of *E. illustris* Raym. (The three genital capsules are drawn at the same magnification.)

Legs black, anterior tibiae red, others black basally, red apically; tarsi reddish-amber; claws reddish-amber; hind calcar straw-colour; tegulae black, with an amber spot; wings slightly dusky; nervures brown, first recurrent entering second cubital cell at its basal fifth; basal nervure strongly arched; pterostigma brownish-amber; hamuli five.

Locality: 90 miles north of Perth, Bolgart, W.A., 1951, leg. Rica Erickson.

Type in the collection of the author.

Allies.—In the *E. rufitarsis* group, but smaller even than *E. albopilosa* Raym., which has long white hair; face not excavated so conspicuously, pale-amber nervures, with the first recurrent meeting the first intercubitus, the second cubital cell much larger; flagellum amber beneath. The new species has its minute apical plate emarginate. The general facies is that of a very small *E. rufitarsis* Raym.

Division MEGACHILIFORMES

Family MEGACHILIDAE

Megachile gilbertiella silvestris, subsp. nov.

One of the grey stalks from the southern locality contained a very small female leaf-cutter bee, which was determined as a new subspecies of *Megachile gilbertiella* Ckll. It differs from the nominate subspecies by its smaller size, larger head, and blacker aspect; the clypeal teeth are practically obsolete; the punctures are largest at the sides, and grow progressively smaller towards the disc; the white hair is peculiar, being finely "crimped" like merino wool; the supraclypeal area is not defined; the red of the apical segments is darker, and much reduced in area.

The female was probably only sheltering in a cavity excavated by *Exoneura*.

The nominate subspecies was described from Cooktown, Queensland, but the senior author has typical females from the following localities:—Broken Hill, November 5, 1940, Royce C. Mew. Woy Woy, New South Wales, December 1934, John Willey.

These records add the species to the fauna of the eastern States.

NOTES ON ARCHITECTURE

The junior author's collections demonstrated that *Exoneura* are numerous in at least the South-west corner of the State, and the number of species will certainly be increased in the future.

The table below will indicate the density of the species in certain areas. A series of 15 flower-stalks of *Xanthorrhoea* was collected simply because each showed a 3 mm. aperture at the top. Almost every flower-stalk contained live bees.

Compared with the smaller greyish-coloured dry stalks favoured by *E. illustris*, those used by *E. pictifrons* were larger, averaging 8 mm. in diameter, and the colour was bright coffee-brown; the length of the communal chambers averaged 17 cm.,

but the bore was still only 3 mm. in diameter, the same as that of *E. illustris*. There was, therefore, a greater thickness of pith surrounding the chamber.

The brown flower-stalks were much tougher, but the differences in colour and structure were not investigated; they could have been due to age or chemical or ecological factors.

It was nevertheless interesting to discover these preferences in bees so closely related. The smaller chambers of *E. illustris* are excavated almost to the woody wall. In both the eastern and the southern localities, the 15 or so flower-stalks from each contained exclusively one species of *Exoneura*, except one stalk from the southern locality, which contained three adults and larvae of the excessively small black species, *E. albopilosa*, Raym. The nesting habits of the black species do not appear to differ from that of the red bees.

CONTENTS OF AUTUMNAL (April) STALKS.

No. of stalk	No. of adults	No. of pupae	No. of larvae
1.	1 mature female 1 mature male	1 male 1 female	nil
2.	3 mature females boring in pith	Nil	Nil
3.	3 mature females boring in pith	1 female	Nil
4.	No bees present. Chamber under construction	Nil	Nil
5.	Same condition as 4		
6.	2 mature females sheltering in old stem	Nil	Nil
7.	2 mature females	Nil	Nil
8.	2 mature females 1 callow female. All boring a new chamber	Nil	Nil
9.	No bees present. Chamber in course of construction	Nil	Nil
10.	2 mature females 1 callow female 1 callow male	1 female	Nil
11.	No bees present. Chamber in course of construction	Nil	Nil
12.	3 mature females	Nil	Nil
13.	1 female boring at the base of a very long chamber	Nil	Nil
14.	1 female in a very short chamber	Nil	Nil
15.	No bees present. Chamber newly constructed	Nil	Nil

The stalks collected in December contained numbers of pollen-puddings, eggs, larvae, pupae, and adults, for each tiny "colony" has then reached its maximum activity. There are probably only two generations for the season, and the chambers in the April stalks were being prepared for the spring generation.

PLANTS VISITED FOR POLLEN.

Fifteen pollen-puddings were removed from the stems and examined microscopically. It would appear that at least six species of plants were represented. The majority of the pollen-grains were triangular in shape, and probably harvested from two species of *Melaleuca;* these may be known as A and B. Two white kinds resemble minute footballs, one was much larger than the other, and there is little doubt that they were gathered from some leguminous plant; the symbols for the table will be C and D. Two other kinds also were triangular, and typical of the genus *Eucalyptus*. The surrounding forest was composed of marri and jarrah trees, but it is impossible to identify the species of pollen; E and F. will distinguish this group.

COMPOSITION OF PUDDINGS.

The following table gives the pereentages of the several kinds of pollen-grains:—

No. of Pudding	A	B	C	D	E	F
1	96	4	—	—	—	—
2	—	60	20	5	10	5
3	—	100	—	—	—	—
4	—	80	18	—	2	—
5	—	97	1	—	2	—
6	—	35	35	30	—	—
7	—	45	40	15	—	—
8	—	95	—	—	—	5
9	—	100	—	—	—	—
10	—	100	—	—	—	—
11	1	97	—	—	—	2
12	—	100	—	—	—	—
13	—	30	—	60	5	5
14	—	100	—	—	—	—
15	—	100	—	—	—	—

CONTENTS OF VERNAL (October) STALKS.

On Oetober 20 1951, twelve dry flower-stalks of the smaller *Xanthorrhoea* were eolleeted at the original site, the 40-mile post, and eleven eontained nests of *Exoneura illustris*. The sticks averaged 18 cm. in length, with a diameter of 6 mm. The bore was 3 mm. in diameter, but where the natural tube—i.e., not bored by the bees—exeeeded that measure, the entranee was eontraeted by the bees with a ring of wood-pulp. The eontents of the stalks are given below:—

No. of Stalk	No. of Adults	No. of Eggs	No. Larvae
1.	2 females	—	—
2.	2 females	9	3
3.	4 females	A few pollen-grains	1
4. Entrance contracted	1 female excavating pith	3	—
5.	3 females excavating pith		—
6.	2 females	14	—
7. Contained a very small 3mm. black spider with microscopic white dots.			
8.	2 females	12	5
9. Boring nearly completed, but no bees were present.			
10. No bees were present		2	—
11.	3 females	8	10
12.	2 females	5	7

The salient features of these spring nests are:—1. The nests are founded by two or more females (sisters). 2. The utter absenee of males; they had fceundated the females the previous autumn and did not survive the winter. 3. The larvae had only just hatehed from the eggs, whieh were laid "eriss-eross" at the base of the chamber. Smear preparations revealed pollen-grains in the larval mesenteron. 4. This brood would be matured for the summer generation.

THE EGG.

The opaque white egg, a mere millimetre or so in length, is slightly bowed, and "glued" on the lumen at the caudal end with a clear secretion from the mueous gland in the apieal segments of the female's abdomen. The eggs are usually deposited in lines, but in certain speeies laid just eriss-cross, loose, in the base of the lumen. This group provides a few pollen-grains among the larvae.

The chorion of the egg splits at the eephalie end, leaving the baby larva projeeting out at right angles from the wall. The gluey

mucous fastening the egg is not brittle, but rather horn-like, for in walking up and down inside the tube the females of necessity often press the larvae back flat against the wall, but they quickly regain their horizontal position.

LARVAL FOOD.

The larvae are fed with a milky "pap" secreted by the female, as has been shown by one of us in another place. The larvae have been observed to "suck their thumbs," so that the appendages are very probably exudatoria. It has been suggested that the males may return to obtain a lipoid from the larval appendages. However, longitudinal and transverse microsections of the "arms" show a canal and many fat-cells.

After 21 or so days, a small individual pollen-pudding, about 2.5 mm. in diameter, is gathered by the mother, and placed on the ventral surface of the larva, which is slightly curved to hold the food up to the mandibles.

It has been amply demonstrated by one of us that the larvae are capable of surviving weeks of fasting, and the period of larval growth is the longest of any bee known to the senior author, for it extends over several weeks (see table, *Australian Zoologist*, vol. 11, pt. 4, 1951, p 309). In an experiment 4 males and 18 females of *Exoneura pictifrons* Alfk. were imprisoned for over 100 days in 11 glass test-tubes (3 in.), which were closed with loose-fitting plugs of cotton-wool. The bees were without food and drink for the entire period, and many survived that long fast. They were kept at a temperature of 10° C., but the experiment was not pressed

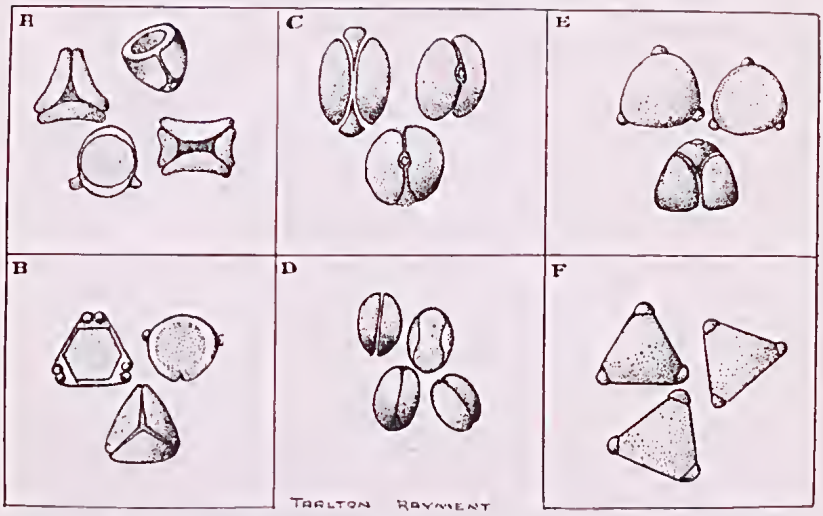

Fig. 4.—Pollen-grains harvested by social bee, *Exoneura illustris* Raym. A and B—Myrtaceous, *Melaleuca* sp. ? (a few abnormal grains in this group were rectangular). C and D—Leguminous, but species unknown. E and F—Myrtaceous, *Eucalyptus* sp. ? All the grains were drawn from glycerine mounts.

beyond the 100 days to aseertain the extreme limit of enduranee.

As in the Eastern States, the busiest period for the western bees appears to be November-Deeember, when adult males and females, eggs, larvae, pupae and puddings are all present in the plant-stems. There arc very probably only two generations for the season.

LARVAL DEVELOPMENT

The actual hatehing of the egg is diffieult to deteet, but traees of segmentation within may he observed. The ehorion of the egg is so exeessively delicate that when it does split, at the eephalie pole, there is just a mieroseopie speek of skin attached to the larva.

The babies are metieulously "groomed" by the adult females, and stroked with the tarsal brushes of the front pair of legs; the "egg-shell" and any other debris is brushed off during these eleansing aetions, whieh maintain the larvae in an immaeulate pearly condition.

Ever and anon, one of the females will take the head of a baby between her jaws, as though sueking a lolly-pop, and then, bending her glossa right back under her head, brings a eavity, the salivarium, on the top of her tongue, over the mouth of the baby. The white soft "pap" then flows into the mouth of the larva. At the eonelusion of the meal any surplus food is wiped away by another female.

The lateral appendages are very small at first, but as the larva grows the proeesses develop into "arms," with two or three "fingers" and a thumb. Several of the eastern species have only one "finger," but the larvae of the western bee have two "fingers" and a "thumb" on the main appendage. As metamorphosis approaehes the appendages are absorbed.

The pupa is quite smooth, that is, it lacks the numerous nodules and spines whieh distinguish the pupa in fossorial bees in the Family Halietidae. It is interesting to learn that the pupae of many spheeid wasps (fossores) are similarly armed with fleshy spines on the scutella, abdominal terga, and legs.

The smooth pupa is typieal of all the higher soeial families of the Apidae, and there is now no doubt that the *Exoneura* are highly developed bees; far higher, in faet, than any other of the solitary wild bees with which they have always been confused.

BEHAVIOUR OF THE INDIVIDUAL

At the mouth of every shaft there is usually one adult bee present, head downwards in the tube, possibly to guard the door against unwanted visitors. The oldest larvae are found nearer the top of the shaft, "mouthing" hungrily as they wait their turn to be fed. At the base are the eggs and also the youngest larvae, together with portions of the pollen-puddings.

Between the two groups an adult bee or two is usually stationed as though in attendanee on the youngest babies. The bees eome and

go from the stalks in a busy traffic. A returning female may have to jostle her way for many seconds at the mouth of the shaft, shoving against the abdomen of the "guard" bee. The latter will at last reverse, in what appears to be a peevish manner, to emerge head first, to fly away. This turning over can easily be accomplished in the diameter of the tube. Any other bees which may happen to obstruct the shaft are likewise jostled until they also reverse or turn about to fly off. The homing female is then able to descend unobstructed into the chamber.

When the bees are excavating a new shaft, in the soft pith of the stem, a fine "fluff" of white shavings covers them, giving a paler dusty aspect to the builders. The nature of their activities when hidden in the interior of the shaft may often thus be detected without destroying the nest.

As the larvae develop they become restless, and gradually work their way up the wall of the shaft in groups of two or three. The lower portion of the body is braced against the walls in a curve and thus maintains its position. The "arms" also are used to support the body, and appear to help it move upwards. When presented with a morsel of food on its "chest" it feeds with the mouth pressed voraciously to the tiny pollen-pudding, which the "arms" prevent from rolling away out of reach. When hungry companions are close alongside, the arm-like appendages are sometimes used to ward them off.

OLFACTORY ORGANS

Anatomists and physiologists agree that bees are able to distinguish one odour from another, but there is a divergence of opinion regarding which organs are olfactory in function. McIndoo (1914) claimed that 18 groups of pore-organs found on hive-bees are the true olfactory organs, but von Frisch (1919) carried out a series of experiments which indicated that other organs of the antennae also function in the detection of odours.

Although most of the above experiments were with hive-bees, yet it would appear, from the senior author's researches, that similar groups of pore-organs are present on wild-bees, and several have been identified on *Exoneura illustris* Raym. and on *E. albopilosa* Raym. There are conspicuous groups near the articulation on the posterior coxae; in the salivarium of the glossa, but we are unable to say whether or not this group is homologous with that found by Mr. McIndoo in the mouth cavity of the honey-bee. Pore-organs are present on proximal and distal ends of trochanters; proximal ends of anterior tibiae; inner margins of prosternal sclerites; proximal end of posterior femora; first segment (pedicel) of flagellum; proximal end of posterior coxae; bases of wings. The organs are perhaps common to all bees.

Under the microscope, pore-organs appear as circles of light enclosed by a dark rim; sections show a dome-like structure under the epidermis, with a slender extension of a sense-cell (Snodgrass, 1925).

Dr. W. H. Thorpe, Cambridge University, reviewing the extraordinary experiments of Prof. K. von Friseh on the honey-bee's ability to orientate itself, suggested that the pull of gravity is presumably perceived by the proprioceptive sense organs at the limb and abdominal articulations.

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INTER-SPECIFIC COMPETITION ON SMALL ISLANDS

By D. L. SERVENTY, Nedlands.

A characteristic of the distribution of some members of the native fauna on the islands around the Western Australian coast is that a species of a closely related group may be found on one island and another species on another. But the two do not exist together on the one island, though all of the species concerned occur on the mainland in the same general geographical area. The facts are best known in the case of the marsupials and the reptiles.

The Quokka *(Setonyx brachyurus)* is found on Rottnest Island and Bald Island on the south coast. The Tammar *(Macropus eugenii)* occurs on East and West Wallaby Islands in the Abrolhos, on Garden Island and on certain of the islands of the Archipelago of the Recherche (North Twin Peaks and Middle Islands). The Rock Wallaby *(Petrogale lateralis hacketti)* inhabits Mondrain, Combe and Salisbury Islands in the Recherche.

Among the snakes the Carpet Snake *(Morelia variegata)* is found on the Wallaby Islands and on Garden Island. The Dugite *(Demansia nuchalis)* is found on Rottnest Island and the Tiger Snake *(Notechis scutatus)* on Carnac and Garden Islands.

All these islands were formerly joined to the mainland and the fauna now represented on them is the survival of that which existed there before the islands were isolated. To account for the present distribution, some ingenious theories have been put forward. J. R. Clarke ("Notes on Natural History of the Quokka," *Journ. Roy. Soc. W.A.*, vol. 33, 1948, p. 141) explains the occurrence of the Quokka on Rottnest and of the Tammar on Garden Island by invoking a theory of inter-specific competition which is unacceptable on modern ecological views.

A more reasonable explanation of the distribution phenomena on these islands may be found in the application of what is coming to be known as "Gause's Law," after G. F. Gause *(The Struggle*